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| **GENETIC PROCESSES Grade 11 (SBI 3U)** | | |
| ***Lesson Sequence*** | ***Lesson Plan Title (Concept)*** | ***Names*** |
| First Lesson | Codominance and Incomplete Dominance | Katie Clay and Lauren Cluff |
| Wet Lab | Blood Typing (codominance) | n/a |
| Second Lesson | Sex Linkage and Sex-Linked Genetic Disorders | Silvia De Sousa and Sasha Moldovan |
| ***Rationale:***  These two lessons appear on Days 12 and 14 of our unit plan. There is a “Blood Typing” wet laboratory on codominance in between the two lessons.  These two lessons help to develop the Big Idea that “variability and diversity of living organisms result from the distribution of genetic materials during the process of meiosis.” Genetic traits governed by codominance, incomplete dominane and sex-linkage all contribute to variability and diversity of organisms such as humans (discussed in second lesson), flowers, chicken (discussed in first lesson), and others. The first and second lessons also discuss how different genes that follow these non-Mendelian patterns may be distributed during meiosis through the use of Punnett squares.  The Big Idea, “genetic and genomic research can have social and environmental implications” is touched upon in the second lesson with discussion of various sex-linked genetic disorders that affect people in our society and all over the world. | | |

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| **GENETIC PROCESSES – Sex Linkage and Sex-Linked Genetic Disorders** | | |
| **Curriculum Connections**  **Big Ideas:**   * Genetic and genomic research can have social and environmental implications. * Variability and diversity of living organisms result from the distribution of genetic materials during the process of meiosis.   **Ministry Expectations:**  *Overall Expectations:*   * Demonstrate an understanding of concepts, processes, and technologies related to the transmission of hereditary characteristics.   *Specific Expectations:*   * Explain how the concepts of DNA, genes, chromosomes, and meiosis account for the transmission of hereditary characteristics from generation to generation (e.g., explain how the sex of an individual can be determined genetically; demonstrate an understanding that the expression of a genetic disorder linked to the sex chromosomes is more common in males than in females); * Use the Punnett square method to solve basic genetics problems involving monohybrid crosses, incomplete dominance, co-dominance, dihybrid crosses, and sex-linked genes * Explain the concepts of genotype, phenotype, dominance, incomplete dominance, co-dominance, recessiveness and sex linkage according to Mendelian laws of inheritance * Describe genetic disorders (e.g., Down syndrome, cystic fibrosis, muscular dystrophy, fragile X syndrome) in terms of the chromosomes affected, physical effects, and treatment;   **Learning Goal:**   * By the end of the lesson students will understand and solve problems involving sex-linked inheritance * By the end of the lesson students will be familiar with a number of sex-linked genetic disorders (e.g. Muscular dystrophy, hemophilia, red-green colorblindness, etc) * By the end of the lesson students will be able to construct a Punnett square and predict the phenotype and genotype ratios involving sex-linked traits   **Prior Knowledge:**   * Students are able to construct a Punnett square for monohybrid and dihybrid crosses with dominant and recessive traits (Days 10 and 11 on Unit Plan) * Students are able to calculate ratios (expressed as fractions and percent) (Day 10 on Unit Plan) * Students understand the process of meiosis (Days 2, 3, 4 on Unit Plan) * Students understand the sources of variation: independent assortment and crossing over (in meiosis) and random fertilization (Days 4 on Unit Plan) * Students understand and are able to use the following vocabulary: autosomal, recessive, dominant, allele, gene, chromosome, homozygous, heterozygous, genotype and phenotype (Unit vocabulary list handed out on Day 1 of Unit Plan and used throughout the unit; see Appendix A3 and B2). * Students have an understanding of sex chromosomes (Day 8 on Unit Plan) | | |  | | --- | | **List Materials**   * Projector * Ppt presentation * Chart Paper and markers * Chalk and Board * Photocopied Student Hand-outs | | **Include in Appendix**   * Instructions for students * Appendix A1: Sex-linked activity worksheet * Appendix A2: Homework worksheet * Appendix A3: Vocabulary list *(students are expected to have this sheet in their notes, if not extra ones should be given out)* * Teacher Resources Appendix B1 and B2 | |
| ***Step-By-Step procedure*** | | ***Rationale for T/L strategy*** |
| ***Minds On (10-12 min.)***  ***Assessment as learning*** *through the think-pair share*  ***Assessment as and for learning*** *through class discussion* | ***Think- Pair-Share Activity (5 minutes)***   * Slide 1 of the power point will be projected onto the board. Students will be asked to pair up with their table partner and discuss the possible solutions to the problem. Students will be given approximately 5 minutes to discuss the answer to the question. During the think-pair-share process, the teacher will walk around to ensure that all students are on task and offer help for those who require assistance.   ***Consolidation of King Henry VIII problem (5 minutes)***   * Students will be asked to share their ideas in classroom discussion as to why King Henry VII should not have blamed his wives for their inability to conceive a son.   ***Teacher led discussion:***   * Students’ answers will lead into **Slide 2** of the Powerpoint (Ppt) presentation. Teacher will ask students the questions to lead the discussion (Refer to Appendix B1) | * The think pair-share will give students the opportunity to discuss their ideas and feel more confident when answering the question in front of the whole class during discussion. * This activity enables cross-curricular connection to historical concepts. * Students are also able to review previously learned concepts. |
| **Action (30 min.)**  ***Assessment for learning*** *through student activity sheet* | ***Mini-lecture on sex-linked inheritance (10 min.)***   * Teacher will lecture about sex-linked inheritance using slides 4-9. Remind students to take out their vocabulary sheet (Appendix A3) so they can add new definitions and take out their note book to copy down important information regarding sex-linked inheritance. * Refer to Appendix B1 for the questions that will be asked to students to guide the lecture and discussion of the lesson.   **P*roblem-based learning in groups (20 min)***  **\*\****Students will be put into groups of 4 based on academic ability.*   * After the lecture get students who are responsible for distributing the handouts to pass a copy of the worksheet to every student (Appendix A1). * Give each group chart paper and markers. Remind students to present their solutions on the chart paper. * The teacher will put up the list of names for the 6 groups and assign each group one question from the hand-out (Appendix A1). Each group will be expected to meet at the designated station. Students will be given 10 minutes to complete the questions | * Ppt lecture was chosen so that both visual and auditory students could be reached. The pictures will enable students to better understand genetic concepts. * Groups were organized based on academic ability so that students who are struggling in this unit can receive assistance from those who are performing well. |
| **Consolidation & Connection**  **(25 min.)**  ***Assessment for and as learning*** *through presentation of answers and classroom discussion* | ***Presentations***   * Each group will present their chart paper containing the Punnet Square and genotypic and phenotypic ratios. * Each group will have approximately 3 minutes to present their solution. * Remind every student in the classroom to copy down the solution as the group is presenting. * After every group has finished presenting, ask students the Key questions outlined in *Appendix B1 (Teacher Questioning and Answer sheet)* | * Having the students present their solutions and teach the rest of the class about the disorder will enable them to better understand the material and enable them to practice their communication skills. * Getting groups to present will enable students to learn about a variety of disorders. |
| **Next Steps:** | Practice problems on sex-linked inheritance for homework (see Appendix A2) | To be taken up in class and peer assessed the following day. |

APPENDIX A

(Student Hand out sheets)

Appendix A1.

**SEX-LINKED INHERITANCE AND GENETIC DISORDERS**

**Instructions for the Activity:**

With your group members, complete parts a) to d) for the problem that you have been assigned (**one** of problems 1 - 6). You will have 7 minutes to discuss and complete the problem.

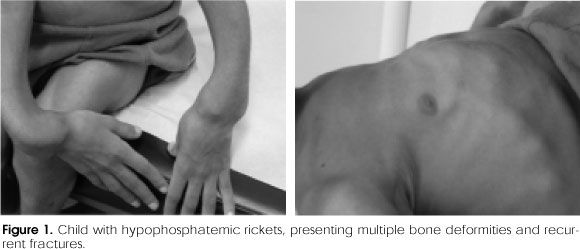
At the end of the 7 minutes, your group will introduce the problem, describe the genetic disorder and present your solution to the whole class. Each group will have 3 minutes to present.

When working in your groups, please, remember to give each person the opportunity to speak and discuss all ideas that are presented.

**Materials:**

* Chart paper
* Markers
* “Sex-Linked Inheritance and Genetic Disorders” hand-out

**Problems:**

1. **X-linked hypophosphatemia** is an **X-linked dominant** disorder that causes problems in phosphate transport and results in the softening of bones. Bone deformity and recurrent fractures are common symptoms of this disease.

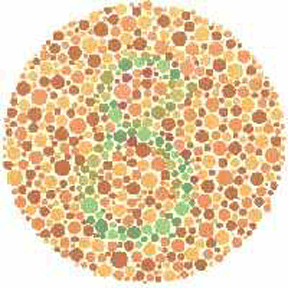
For a female who is a carrier of the X-linked hypophosphatemia gene and a normal male, answer the following questions:

1. Create a Punnett square to show possible assortment of the X-linked hypophosphatemia gene.
2. Determine the genotypes AND phenotypes of possible children.
3. What percent of possible children would be affected by this disorder?
4. How many of these affected children are female? How many are male?
5. **Duchenne Muscular Dystrophy** is an **X-linked recessive** disorder that involves rapidly worsening muscle weakness. Duchenne muscular dystrophy is caused by a defective gene for dystrophin (a protein in the muscles). Symptoms usually appear before age 6 and may appear as early as infancy. By age 10, the person may need braces for walking. By age 12, most patients are confined to a wheelchair.

For a female who has Duchenne Muscular Dystrophy and a normal male, answer the following questions:

1. Create a Punnett square to show possible assortment of the X-linked Duchenne Muscular Dystrophy gene.
2. Determine the genotypes AND phenotypes of possible children.
3. What percent of possible children would be affected by this disorder?
4. How many of these affected children are female? How many are male?
5. **X-linked severe combined immunodeficiency (SCID)** is an **X-linked recessive** disease. It is often called “bubble boy disease” because one patient, David Vetter, lived in a plastic, germ-free bubble for 12 years. The defining characteristic of SCID is a severe defect in T- & B- lymphocytes, which are an important part of the immune system.

For a female who is a carrier of the X-linked SCID gene and a normal male, answer the following questions:

1. Create a Punnett square to show possible assortment of the X-linked SCID gene.
2. Determine the genotypes AND phenotypes of possible children.
3. What percent of possible children would be affected by this disorder?
4. How many of these affected children are female? How many are male?
5. **Red-Green Colour Blindness** is an **X-linked recessive** disorder. The retinal cones which perceive color in light do not develop properly, thus they are not able to transmit the information to the optic nerve. People who are affected by this disorder are unable to distinguish between red and green colours. As a result, patients with Red-Green color blindness are unable to locate the number on this picture. Suppose you were to cross a **normal male** and a **female carrier**:
6. Create a Punnett square to show possible assortment of the X-linked Colour blindness gene.
7. Determine the genotype AND phenotype of the children.
8. What percentage of children would be affected by this disorder?
9. How many of the affected children are male? How many are female?
10. **Hairy Ears** is a **Y-linked disorder**, whereby coarse hairs develop on the pinna of the ears (see picture to the right). Suppose you were to cross an **affected male** with a **normal female**:
11. Create a Punnett square to show the possible assortment of the Y-linked Hairy Ear gene.
12. Determine the genotype AND phenotype of the children.
13. What percentage of children would be affected by this disorder?
14. How many of the affected children are male? How many are female?
15. **Hemophilia** is the oldest known **X-linked recessive** bleeding disorder. Patients with hemophilia have less than 1% of the normal amount of clotting factors in their blood. A small cut can cause these patients to bleed excessively or even bleed to death. Suppose you were to cross an **affected male** and an **affected female**:
16. Create a Punnett square to show the possible assortment of the X-linked hemophilia gene.
17. Determine the genotype AND the phenotype of the children.
18. What percentage of children would be affected by this disorder?
19. How many of the affected children are male? How many are female?

Appendix A2.

**Homework Problems on Sex-linked Traits and Disorders:**

1. A woman who is a carrier for colour vision deficiency (CVD) and a man who has CVD decide to have children. CVD is an X-linked recessive disorder.
2. Determine the genotypes of these two people
3. What is the expected ratio of genotypes and phenotypes among children?
4. The mother and father of a boy who has CVD both have normal colour vision. Use a Punnett square to explain how this can occur.
5. Haemophilia is an X-linked recessive disorder. A woman with haemophilia and a man without haemophilia decide to have children. What is the probability that their sons will have haemophilia?
6. Nystagmus is a condition in which involuntary eye movement leads to poor vision. This condition is caused by an X-linked recessive allele. Suppose that a man and woman, both with normal vision, have two children. The boy is affected with nystagmus, and the girl is unaffected.
7. Determine the genotype of the parents
8. Is it possible to determine the genotypes of the children? Why or why not?
9. A woman has X-linked hypophosphatemia, which affects bone development. She marries a man with normal bone structure. If the woman’s father also has normal bone structure, what is the probability that the woman and her husband will have a child with the disorder?
10. A woman with regular vision and a man with regular vision have three children, one of whom has CVD.
11. What can you conclude about the genotypes of the parents?
12. What sex is the child who has CVD? How do you know?

Appendix A3.

**GENETICS VOCABULARY**

Please, write definitions for the following terms in genetics as we go through this unit. You may refer to the glossary, which can be found at the back of your textbook. Try to write the definitions in your words.

**Allele** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Autosomal inheritance** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Autosome** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Barr body** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Codominance –** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Dihybrid cross** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Dominant** –\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Expression** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**F1 generation** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**F2 generation** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Gene** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Genetics** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Genome** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Genomics** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Genotype** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Haploid** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Heterozygous** - \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Homozygous** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Incomplete dominance** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Karyotype** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Law of independent assortment** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Law of segregation** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Linked genes** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Mendelian ratio** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Monohybrid cross** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Multiple alleles** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Order of dominance** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**P generation** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Pedigree** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Phenotype** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Polygenic trait** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Probability** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Punnett square** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Recessive** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Sex chromosome** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Sex-linked trait** –\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Test cross** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Trait** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**True breeding** –\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Variation** –\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**X-linked gene** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

***APPENDIX B***

(Teacher Resources)

Appendix B1.

***Teacher Questioning Sheet and Answers***

***PART I: Minds On***

* *Possible answers for the King Henry VIII Problem:*

King Henry VIII should not have blamed his wives because women have XX chromosomes, whereas men have the XY chromosome. Men are responsible for passing the Y chromosome on to the progeny, which in turn creates a male child.

* After students have finished discussing their answers to the Henry VIII problem, turn to Slide 2 and ask students the following questions:

1. *In reference to this Punnet square (Slide 3), what is the phenotype?*

**A:** 50% male, 50% female

1. *What is the expected genotype?*

**A:** 50% XX, 50% XY

1. Slide 3: *What are some genetic conditions that arise from unusual pairing of the sex-chromosomes?*

**A:** Tuner Syndrome (XO), Trisonomy X (XXX), Klinefelter (XXY), some males have an extra Y (XYY)

1. *Why does nature favour XX and XY complements?*

**A:** Nature doesn’t favor the abnormal sex complements because it can result in infertility and unusual physical appearances.

***PART II: Action (Slides 3-8)***

* Go through each slide and ensure that students are also copying the notes from the ppt presentation. Remind students to copy down all of the definitions from Slide 4 onto their *“Vocabulary Sheet”* (Refer to Appendix A).
* The following questions will be asked so that students can be involved in the discussion:

1. Slide 5:*What are the 2 sex chromosomes that males inherit?*

**A:** XY

* Explain to students that because males only have 1 copy of each sex chromosome that they will only have 1 copy of the X- linked trait. In comparison to the female who will have 2 copies of the sex-linked trait because they have 2 copies of the X-chromosome. (Remind students to write this additional information onto their note package)

1. Slide 6:*What is a dominant gene?*

**A:** When one gene will mask the effects of another gene.

*e) What is a recessive gene?*

**A:** Will only express a trait when the individual is homozygous. IT can be masked by a dominant gene.

* Slide 7:Explain how the recessive and dominant genes can be represented with uppercase letters. Remind students that this method of representation differs from the previous Punnett squares they have seen.
* **Slide 8:** Before showing the results of the Punnett square give students (2 minute) to finish off the Punnett Square and predict the phenotype and genotype.

1. *Can anyone tell me what the outcomes of the Punnett Square will be?*

**A:** XHXh, XHXh, XHY, XhY

1. *What are the phenotypes of this Punnett Square?*

**A:** 2 normal females, 1 normal male, 1 color blind males

1. *What are the possible genotypes?*

**A:** 25% XHXH , 25% XH Y, 25% Xh XH,25% Xh Y

***PART III: Consolidation/Debrief***

* After each group has finished presenting their solutions ask the group members the following questions. The answers will vary depending on the group presenting.

1. *Which gender is most often affected by the disease? Why?*
2. *Which gender is typically the carrier of sex-linked genetic disorders?*

* Once all of the groups have presented the teacher will ask this question to get students thinking about the evolutionary aspect of inheritance.

1. *Why is the majority of sex-linked genetic disorders X-linked recessive? What is the evolutionary advantage of this?*

**A:**This way there is a lower percentage of females that are effected. If it were dominant every female would have the disease. This in turn would lead to a greater percentage of the population being affected*.*

Appendix B2.

**GENETICS VOCABULARY Teacher Copy**

**Allele** – one of two or more forms of a gene

**Autosomal inheritance** – the inheritance of traits determined by genes on the autosomal chromosomes

**Autosome** – a chromosome that is not involved in determining the sex of an organism

**Barr body** – of the two X chromosomes in the cells of a female individual, the one that is inactivated at an early embryonic stage

**Codominance –** the condition in which both alleles for a trait are equally expressed in a heterozygote; both alleles are dominant

**Dihybrid cross** – a cross of two individuals that differ in two traits due to two different genes

**Dominant** – describes the form of a trait that always appears when an individual has an allele for it; an allele that causes expression of a phenotype whenever it is present

**Expression** – the production of a particular protein from a gene; also the level of production of a particular protein from a gene

**F1 generation** – the first filial generation; the offspring of a cross of the P generation

**F2 generation** – the second filial generation; the offspring of a cross between individuals from the F1 generation

**Gene** – a part of a chromosome that governs the expression of a trait and is passed on to offspring; it has a specific DNA sequence

**Genetics** – the field of biology that involves the study of heredity and variation of living organisms and how genetic information is passed from one generation to the next

**Genome** – the complete DNA sequence of an organism

**Genomics** – the study of genomes and the complex interactions of genes that result in phenotypes

**Genotype** – the combination of alleles for any given trait, or the organism’s entire genetic make-up

**Haploid** – describes a cell that contains half the number of chromosomes as the parent cell

**Heterozygous** - an organism that has two different alleles of a gene

**Homozygous** – describes an organism that has two identical alleles of a gene

**Incomplete dominance** – a condition in which neither allele for a gene completely conceals the presence of the other; it results in intermediate expression of a trait

**Karyotype** – a photograph of pairs of homologous chromosomes in a cell

**Law of independent assortment** – the law that states that during gamete formation, the two alleles for one gene segregate or assort independently of the alleles for other genes

**Law of segregation** – the law that states that traits are determines by pairs of alleles that segregate during meiosis so that each gamete receives one allele

**Linked genes** – genes that are on the same chromosome and that tend to be inherited together

**Mendelian ratio** – a ratio of offspring phenotypes reflecting Gregor Mendel’s law of inheritance

**Monohybrid cross** – a cross of two individuals that differ by one trait

**Multiple alleles** – more than two alleles for one gene

**Order of dominance** – the sequence that describes the dominance relationship between alleles for a gene that has multiple alleles; greater than (>) means *is dominant to* and less than (<) means *is recessive to*

**P generation** – the parental generation; in breeding, the organisms that are initially crossed and are typically true breeding

**Pedigree** – a flowchart that uses symbols to show the inheritance patterns of traits in a family over many generations

**Phenotype** – the physical and physiological traits of an organism

**Polygenic trait** – a trait that is controlled by more than one gene

**Probability** – the chance or likelihood of a particular outcome; usually expressed as a ratio

**Punnett square** – a grid used to illustrate all possible genotypes and phenotypes of offspring from genetic crosses

**Recessive** – describes the form of trait that only appears when an individual has two alleles for it; an allele that must be present in two copies for the phenotype to be expressed

**Sex chromosome** – an X or Y chromosome, which determines the genetic sex of an organism

**Sex-linked trait** – a trait controlled by genes on the X or Y chromosome

**Test cross** – a cross between a parent of unknown genotype and a homozygous recessive parent

**Trait** – a specific feature or characteristic exhibited by an organism

**True breeding** – describes organisms that exhibit the same traits, generation after generation

**Variation** – differences between individuals, which may be structural, functional or physiological

**X-linked gene** – a gene that is found on the X chromosome